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LIMING THE SOIL

BY M. A. BACHTELL

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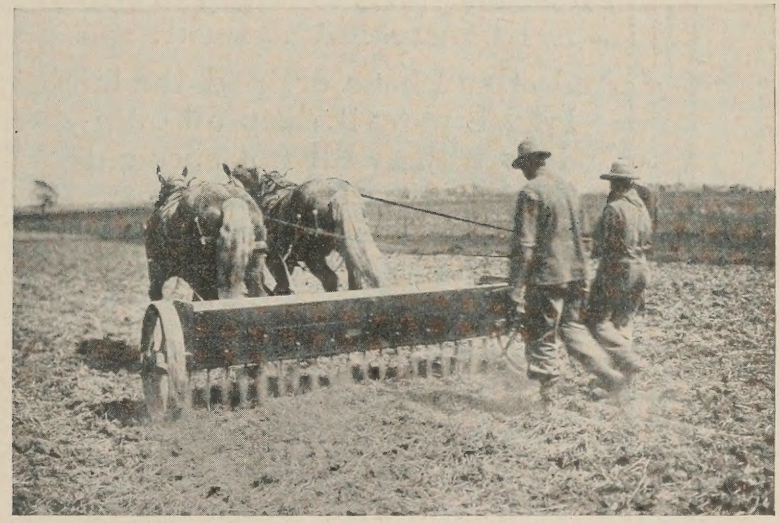

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COLUMBUS

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THE WISE FARMER

THERE WAS a man in our town
And he was wondrous wise
He knew that if he wanted crops
He'd have to fertilize.

"It's nitrogen that makes things green"
Said this man of active brain;
"And potash makes the good strong straw,
And phosphate plumps the grain.
But its clearly wrong to waste plant food
On a wet and soggy field;
I'll surely have to put in drains
If I'd increase the yield.

And after I have drained the land
I must plow it deep all over;
And even then I'll not succeed
Unless it will grow clover.
Now acid soils will not produce
A clover sod that's prime;
So if I have a sour soil,
I'll have to put on lime.

And after doing all these things,
To make success more sure,
I'll try my very best to keep
From wasting the manure.
So I'll drain, and lime, and cultivate,
With all that that implies;
And when I've done that thoroughly
I'll manure and fertilize.

·COLLEGE·OF·AGRICULTURE·
·OHIO·STATE·UNIVERSITY·

VIVIAN

LIMING THE SOIL[1]

BY M. A. BACHTELL

Liming the soil is not a new practice, but in many localities is an uncommon one. In some cases this is because the practice has never been commenced; in others it is because it fell out of use before the advent of the present generation. The use of lime in agriculture was common long before the Christian Era. The Chinese used it but probably more as an insecticide than for any effect which it might have on the soil. Writers of early Roman times spoke of the use of lime and landplaster for agricultural purposes. It was through the Romans that the practice of liming the soil was introduced into England and France. In England farmers long have practised digging the soft chalk from the hills and spreading it on their fields. Enormous quantities have sometimes been used in this way. Indeed, it is said that the farmers in some places value chalk second only to manure. In United States chalk is not plentiful but limestone occurs in great abundance. Limestone and chalk have practically the same composition, the main difference between them being one of hardness, or density. Limestone and chalk both contain lime.

Growing of alfalfa made possible by using lime.

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[1] This article was published as the September 1913 Extension Bulletin. The edition is entirely exhausted and it is reprinted at the request of many who desire a copy of the article. The article is slightly rearranged.

LIME

The term lime is used loosely to denote compounds which contain the elements calcium in combination with other elements. Thus, it may combine with oxygen, oxygen and hydrogen, or with oxygen and carbon. Strictly speaking, the first combination, i. e., calcium combined with oxygen, is the one which bears the name of lime. Calcinm, carbon, and oxygen, when combined, form what is called carbonate of lime, which occurs naturally in limestone. This combination can be destroyed provided enough heat is secured. Consequently, when coal or wood mixed with limestone in a kiln is burned, the result is a breaking down of the stone. When this occurs carbon dioxide is driven off, leaving lime (calcium combined with oxygen). This is also called quicklime, burnt lime, and caustic lime. When 100 pounds of carbonate of lime are burned, 56 pounds of quicklime are secured. Limestone is never 100% pure carbonate of lime, but even though it contains 10% of impurities there will be secured 1008 pounds of quicklime from the burning of one ton. Inasmuch as limestones, which are considered valuable enough to quarry, contain from 3% to 25 or 30% of impurities it can be seen that on the average one-half ton of quicklime is the equal of one ton of limestone. When quicklime comes in contact with moisture it becomes water slacked, or hydrated, lime. In this way the 56 pounds of quicklime secured by the burning of 100 pounds of limestone will increase in weight to 74 pounds. If all forms were pure, 56 pounds of quicklime would equal 74 pounds of hydrated lime and 100 pounds of limestone. Consequently, 74 pounds of hydrated lime and 100 pounds of limestone are also equal. The following table shows a comparison of the different forms of lime.

1 Ton of	Symbol.	Equivalent to Calcium Oxide Pounds.	Equivalent to Hydrated Lime Pounds.	Equivalent to Limestone Pounds.
Quicklime	CaO	2,000	2,643	3,570*
Hydrated Lime	$Ca(OH)_2$	1,514	2,000	2,702
Limestone	$CaCO_3$ ...	1,120	1,614	2,000
Agricultural Lime	?	?	?	?

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*In practice it is customary to consider 1 ton of quicklime equal to 2 tons of limestone because of the fact that the latter usually contains particles more or less coarse which are not acted upon as readily as the finer material.

It has been said of lime that it is "Nature's greatest and most universally applicable enricher of the soil." This is hardly true yet it is a fact that a limestone soil is usually a fertile one. The famous Bluegrass sections of Kentucky may be cited in proof of this. These sections are noted not only for their fertility but also for the fine class of live stock which they produce. This suggests that perhaps there may be a correlation between the quantity of lime in the soil and the quality or finish of the animals which are raised on that soil's vegetation. On the other hand, there are vast areas in the United States which are not fertile and if it is true that lime is a universal enricher of the soil it would seem to be the proper thing to give these areas an application of that material.

There is in the minds of a great many people a hazy idea that anything which is purchased for the purpose of applying to the soil should be classed as a fertilizer. Webster says "fertilize" means "to enrich." But a distinction must be made between apparent and real enrichment. The word, fertilizer, is used to include only those materials which contain one or more of the following kinds of plant food, viz: nitrogen, phosphorus, and potassium. The use of a fertilizer is justified when there is a deficiency in the soil of any of the above named plant foods. Lime on the other hand, does not contain any of these elements, and therefore, does not come in the fertilizer class. The use of lime will not in itself increase the quantity of nitrogen, phosphorus, or potassium which a soil contains. It must be used for other reasons.

When a soil contains a relatively large quantity of iron and aluminum and a relatively small quantity of lime it usually happens that the phosphorus of the soil is locked up or held in combination with the first named elements, which is an undesirable condition. Liming the soil tends to cause the iron and aluminum to give up the phosphorus which is then taken over by the lime. Combined with lime the phosphorus is in a better form for the nourishment of the plant. Thus, it may be seen that although lime contains no phosphorus, its application may give very much the same results as would be secured by a light application of a fertilizer which does contain it.

The potassium of the soil is made more available in a similar manner. Nature has been wise in locking up the potassium in rather unavailable forms; otherwise, many men would not hesitate to use it rapidly and thus actually deplete the fertility of their farms. These forms of potassium are so unavailable that in some cases, where it is known that the soil contains a large quantity of potassium the appearance of the growing crop indicates the need of this plant food. When lime is placed in the soil and comes in contact with the compounds of potassium a change takes place which in chemistry is called a substitution. In other words the lime takes the place of the potassium in the compound, thus leaving it in available form for the plant roots to assimilate. From this it may be seen that as this action takes place some of the results obtained by applying a fertilizer containing potassium will be secured by the practice of liming.

USE OF LIME

Dr. H. J. Wheeler, who for a considerable time was director of the Rhode Island Experiment Station and who is considered an authority on lime says, "A study of the history of liming in England and the United States shows that there have been periods when the practise became quite common owing to the fact that as soon as the benefits from liming are noticed in a given locality it becomes general and the tendency is to carry it to excess and, in consequence of its beneficial influence lasting for 10 to 20 years, a successive period of disuse naturally follows." From this we might infer that there is a right and a wrong way of using lime; a right way, which will give beneficial results; a wrong way, which is not hedpful but harmful. Undoubtedly, it has a wider field of usefulness than its use in the past would indicate. Still, like commercial fertilizers, lime should be used with discrimination, its use depending on the soil and its condition.

Destructive Use of Lime.—Although the results secured by applying lime might be similar for a time to those obtained by using fertilizers containing phosphorus and potassium yet there is a difference. When such a fertilizer is used some plant food is added to the soil and, if the quantity returned is equivalent to that removed by the crop, the supply in the soil has not been diminished. But, when lime has been used to liberate some phosphorus and potassium and these in turn are used by crops the soil has been depleted of some of its original fertility. When used in this way it is only a question of time until the soil will fail to respond to liming as it once did. The process of tearing down has been going on without a corresponding up-building. It was for this reason that the European farmers framed the proverbial expression:

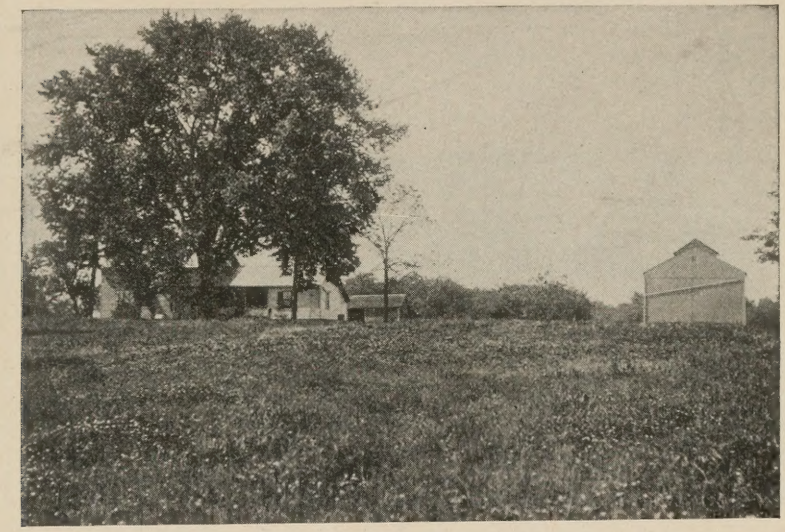
"Lime, and lime without manure
Make both farm and farmer poor."

However, that saying has been supplemented by another, originating from Professor Vivian of the Ohio College of Agriculture, so that it now reads:

"Lime and lime without manure
Make both farm and farmer poor,
But lime, manure, and vigorous clover
Make the old farm rich all over."

Building-up Use of Lime.—In contrast to the destructive use of lime, the building-up use of lime is beneficial. There is a building-up use of lime because of the fact that very often more clover can be grown after the soil has been limed than was possible before this was done. The increased growth of clover made possible by the lime is the real soil builder. To understand just how clover helps to build up the soil it will be necessary to leave the subject of lime for a short time.

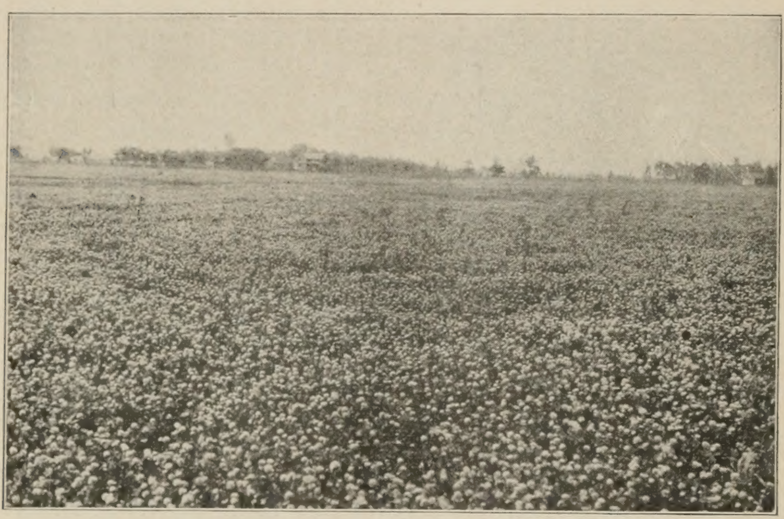
The best growth of clover is closely associated with the presence on the clover roots of little swellings commonly called nodules, or tubercles. These nodules are the home of small organisms known as bacteria. These bacteria live on the roots of clover and take nitrogen from the soil air and furnish it to the clover. The clover is helpful to the bacteria as it furnishes a home and partial sustenance for them; the bacteria are of aid to the clover as they in their turn supply food for this crop.



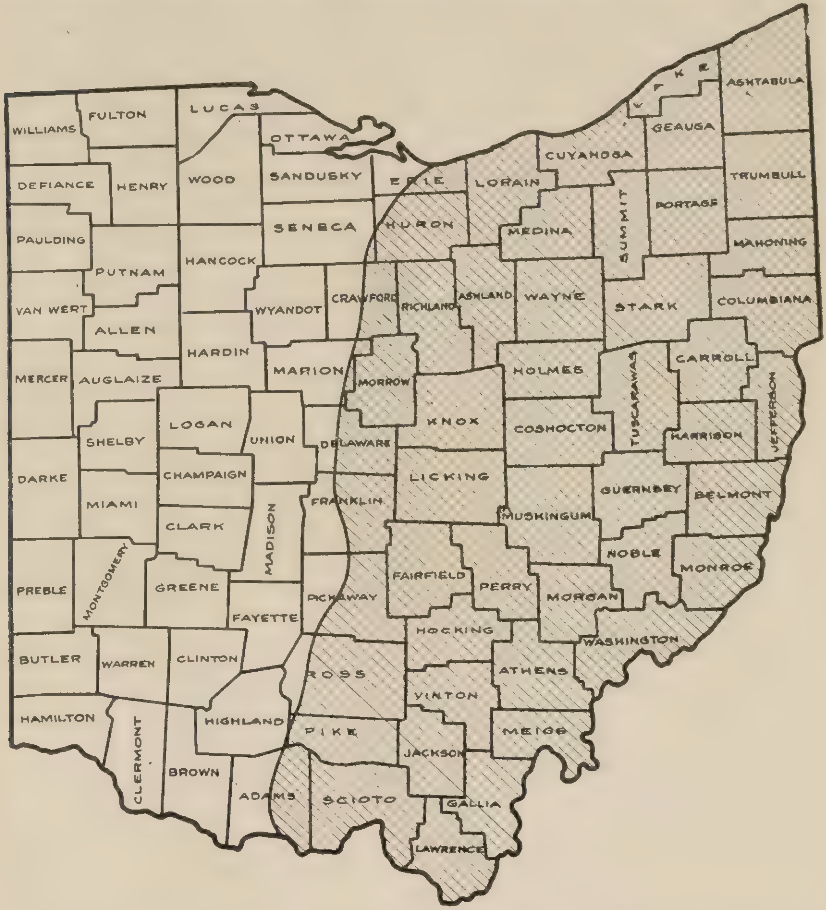
An uneven growth of clover on an acid soil.

The presence of the bacteria is necessary for the normal growth of the legume. But in order to have the bacteria flourish to best advantage it is necessary to have the soil in proper condition. A soil deficient in lime is sour, or acid. In the presence of acid it is impossible for the bacteria properly to do their work of taking nitrogen from the air. When the work of the bacteria is affected, the growth of the legume on which they are living is arrested. There are vast areas in Ohio where the soil have become sour, or acid, and as a consequence it is no longer easy to secure a good crop of clover until the soil has been limed.

Effect of Using Lime.—The effect of liming is well illustrated by the experience of a large number of farmers. Of late years their meadows and pastures have become, in many instances, a failure. They have failed in getting the fields to grow clover and timothy as in former years. They prepare the land the best they know how, manure and fertilize all they think they can afford and sow more seed than they did years ago. The clover and timothy germinate and make a start but as the months pass along the seeding becomes thin, weeds taking the place of the clover and timothy. Sometimes they attribute it to the drouth, at other times to the frost, then again the season was not right in some other way. But some of these men have purchased lime and applied it to their soil at some convient time in the rotation, possibly, as they were preparing their seed bed for corn or wheat. These grain crops may not have been materially affected by the liming; the main thing they were after was clover and they got it. There may be spots where for some reason no lime was applied and there clover is lacking; but the remainder of the field has a fine growth, and this despite the fact that the whole field was cultivated and fertilized alike.


An even growth of clover made possible by liming.

Liming the soil is done principally for the purpose of inrceasing the clover crop. However, on many acid soils there no doubt will be material increase in the yield of other crops following an application of lime. It will be noticed that they will be greener and have a more thrifty appearance. This is because the bacteria which cause the organic matter of the soil to decay and those which cause nitrification, the process by which nitrates are formed, are also enabled to carry on their work more effectively because of the sweetened condition of the soil, due to the lime. Notwithstanding this fact, when lime is applied, the increase is to be sought in the clover crop. However, increasing the growth of the clover may be expected to increase the crops which follow, because, as is well known, that crop has a beneficial influence on the fertility of the



IN EASTERN OHIO THE NEED FOR LIME IS IMPERATIVE;

WESTERN OHIO SOILS HAVE A GREATER NATURAL SUPPLY.

soil. This beneficial effect is due in part to the addition of nitrogen to the soil; the more clover the more nitrogen. Then, if this nitrogen is supplemented with phosphorus and potassium in commercial fertilizers, the plant-food requirements for maximum yields of other crops will be met. By feeding these crops on the farm a liberal quantity of manure is going to be available for use wherever needed. Thus the saying,

"Lime, manure, and vigorous clover
Will make the old farm rich all over" —

is literally carried out.

Another marked effect of the use of lime is, that where lime in sufficient quantities has been evenly applied, no sorrel is to be seen, but on the unlimed spots, it is quite visible among the thin grass. Some men have led themselves to believe that manure will eliminate this difference, but even when the land is cultivated, fertilized, and manured alike, growth of grass on the unlimed part does not in any way equal that which is obtained where lime has been applied. This is an indication of what is in fact true, that manure can not take the place of lime.

Too many farmers regard manure as a cure-all for every trouble which arises concerning the soil. Manure supplies the much needed humus and plant food to the soil and in this respect lime cannot take the place of manure. The same is true of lime in reference to commercial fertilizers. The latter are used for the purpose of adding plant food to the soil and, therefore, cannot take the place of lime in correcting soil acidity. It is even true that the use of certain fertilizers produces a more imperative need for lime. This is not to be used as an argument against the use of those fertilizers, but rather for the consistent application of lime on these soils that need it. A proper use of commercial fertilizers is profitable, but it is impossible to get the maximum returns from fertilizers applied to acid soils.

Although the reason for the liming of soil is to correct soil acidity, other benefits may be secured indirectly; one of which is bettering the physical condition of heavy clay soil. From 1 to 2 tons of lime to the acre should make considerable difference in the ease of handling some heavy soils. It is doubtful, however, whether it would be a profitable thing to lime the soil merely for the purpose of bettering its physical condition.

LOSS OF LIME

For various reasons cultivated soils are continually losing some of their lime. First, the water which percolates through the soil and drains away beneath is continually dissolving some lime. Experiments at Rothamstead Station in England show an annual loss in this way varying from 500 to 1000 pounds per acre. Second, the practice of plowing under heavy sods and green manuring crops tends to lessen the quantity of lime because, as the vegetable matter thus returned to the soil decays, its decomposition is attended by the formation of organic acids. Some of these acids are rendered harmless by combining with lime but this action has left the soil poorer in that compound. This does not mean that the practice of green manuring is a poor one. Green manuring is capable of much good, if properly conducted, but on acid soils the practice should go hand in hand with liming. Third, the use of certain commercial fertilizers tends to remove varying quantities of lime from the soil. Ammonium sulphate, acid phosphate, and muriate of potash are some fertilizing materials which act in this way. This does not mean that it is poor practice to apply those fertilizers that tend toward soil acidity, but it does mean that if they are used, some attention must in time be paid to returning the lime which their use has removed.

Acid phosphate, in particular, is objected to by many farmers on the assumption that its long continued use sours the soil. These men give their preference to some form of bone meal. Their argument is that they can secure more clover by the use of bone than by the use of acid phosphate. Their contention seems to be borne out by the results of experiments at the Ohio Agricultural Experiment Station, located at Wooster. Two plots of land have been receiving the same quantity of plant food in complete fertilizers but the phosphorus in the one has been carried in the form of acid phosphate; in the other, in the form of bone meal. Bulletin 279 of the Ohio Agricultural Experiment Station gives the average yield of clover hay for the years 1903-1913 as 2,796 pounds per acre on the plot receiving the fertilizer containing acid phosphate but 3,135 pounds per acre on the plot receiving the same quantity of phosphorus in bone meal. However, one-half of each plot has been limed and on the limed half the yield of clover hay has been 3,631 pounds per acre where the carrier of phosphorus was acid phosphate and 3,981 pounds where the carrier was bone meal. On other crops the phosphorus in acid phosphate has produced greater yields than the same amount in bone meal. When it is known that the supply of bone meal is limited and that acid phosphate contains a readily available form of phosphoric acid, the desirability of using some acid phosphate becomes apparent. For best results on soils tending to be acid, lime also should be used. On these same soils lime and acid phosphate systematically applied will give better results than bone meal without the lime.

SOILS IN NEED OF LIME

Lime is needed to correct the acids which are continually being formed in soils under cultivation. Such soils vary in their natural supply of lime; those in which it is deficient show a tendency to become acid, or sour. Muck beds, upland soils of non-limestone formation, and soils derived from sandstone are usually deficient in content of lime. This is shown in an interesting way in Ohio. Three-fourths of Ohio was at one time covered by a glacier. This massive sheet of ice moved down from the north, in western Ohio passing over beds of limestone. The grinding action of the ice and its subsequent melting left more or less of this limestone distributed throughout the soil of that area. But in eastern Ohio, the path of the glacier was over sandstone and shale. Inasmuch as these rocks contain very little lime the resulting soil was naturally left deficient in that constituent. In southern Ohio, which was not glaciated, there is a wide variation in the quantity of lime in the various soils, depending on the manner of formation and on the original rock. Although there are some soils naturally deficient in lime and some by nature well supplied, yet it is only a matter of time until all the soils of Ohio will be lacking in this important factor of a fertile soil.

INDICATIONS OF SOIL ACIDITY

Inasmuch as the use of lime will be general only on acid soils it is important to know when and where such conditions exist. There are some things that give a probable answer; others that give an exact answer to this question. In looking over the map of Ohio and taking into consideration the method of formation of the soil one cannot fail to be impressed with the possibility that there may be a deficiency of lime in the greater part of the state east of a line drawn from north to south and running through Sandusky and Columbus. The vegetation growing in this part of the state serves to strengthen this conclusion. A trip in the early part of the summer reveals on every side large patches of sorrel, in some localities this being so well distributed that the pastures when viewed at a distance take on a reddish hue. The growth of sorrel is not a sure indication that acid conditions exist but its continued appearance year after year is a very strong one. Added to this, the fact that over a large part of the area where sorrel grows, a satisfactory crop of clover is secured with increasing difficulty makes the indication doubly strong. The clover may catch but when the small grain crop is removed it begins to die out, becoming thinner and thinner until at time of cutting there are large patches containing very little clover, most of the growth being timothy and weeds, and a large part of the weeds, sorrel.

TESTS FOR SOIL ACIDITY

When the above condition concerning the sorrel and clover are observed, an accurate test should be conducted to settle definitely the question as to the need of lime. This can be done in two ways. One is by means of blue litmus paper, which is so made that it will turn to a reddish tint when it comes in contact with any acid. If some of the surface soil is scraped away and litmus paper pressed against the moist earth, it should turn red in the course of 10 to 20 minutes if acid conditions exist in that soil. The test with litmus paper is a fair and a true one, but a test, which is better than litmus paper is the actual trying of lime. This can be conducted on a few square rods in some part of the field, or better still strips can be run the whole length of the field. If on those strips where lime has been applied the growth of clover is more vigorous than elsewhere, the value of lime is shown. On those farms where fertilizer and manure have been applied the test is conclusive. If the clover crop is increased lime can probably be applied with profit. On those farms, however, where the use of fertilizer is unknown, a second strip should be treated with a fertilizer containing a high per cent. of phosphoric acid and some potash. If this strip brings a greatly increased yield of clover it indicates a lack of plant food rather than of lime. On many Ohio farms the clover crop is failing as much because of lack of plant food as because of soil acidity.

FORM OF LIME TO BE USED

The choice of the material to use will depend in part on the ease of handling and in part on the cost. Quicklime is a cheaper form than hydrated lime, but there is apt to be some inconvenience connected with its use caused by the bursting of sacks and irritations where this caustic form comes in contact with the moist skin. Consequently this form is sometimes used by those who have facilities for burning their own lime or those who, because of favorable location and short haul, are able to apply it very soon after shipment. Hydrated lime shipped in sacks is in a convenient form for handling. However, it requires nearly 2650 pounds of this form to equal 2000 pounds of quicklime. On this basis to make it equally cheap, hydrated lime should be purchased for about three-fourths of the price of quicklime. When the price is practically equal, hydrated lime is an expensive form.

Ground limestone deserves the earnest consideration of those who contemplate liming the soil. A natural product, it can be used in any quantity without danger of injury to the soil. Experiments at the Ohio Station have shown that 2 tons of limestone are as efficient as 1 ton of quicklime, provided the former is finely ground. Limestone is considered finely ground when three-fourths of it will pass through a sieve having 100 meshes to the inch. When 2 tons of limestone can be purchased and spead on the soil at an equal or less cost than 1 ton of quicklime or 2650 pounds of hydrated lime, the limestone should be used. Limestone siftings sometimes can be secured. Although rather coarse, there is enough fine material present to justify their use, provided they can be purchased at a price which will make it practical to use 4 or 5 tons per acre.

Agricultural lime is a variable product. This, as well as other forms should be purchased on the basis of calcium oxide (CaO) or calcium carbonate ($CaCO_3$) which they contain. The Ohio law says, "The term agricultural lime * * * shall include all quicklime, both lump and ground, ground limestone, ground or pulverized oyster shells, sulphate of lime or plaster, hydrated lime, gas lime, marl and all other similar products." In Ohio the analysis of limes for agricultural purposes is now prescribed by law. This law says that whoever manufactures, sells or offers for sale any agricultural lime to be used as a fertilizer or land improver shall furnish with each bulk a chemical analysis stating the minimum percentage of calcium oxide, the minimum and maximum percentage of magnesium oxide, the minimum percentage of carbonate of lime and the minimum percentage of carbonate of magnesium.

Limestone sifting or screenings. They are cheap, but effective.

QUANTITY OF LIME TO BE USED

An application of 1 ton of quicklime or 2 tons of ground limestone per acre is sufficient for the average acid soil. Very acid soils require one-hlaf more than this. Four or five years later this should be followed by another application equivalent to 1 ton of limestone; this to be repeated once during each rotation thereafter.

TIME TO APPLY LIME

There is, no doubt, a best time to apply lime. That time probably is during the preparation of the seed bed for corn. The thorough cultivation of this crop mixes the lime with the upper soil. By the time clover is sown on that soil the lime has changed it from a sour to a sweet condition. This time, however, admits of wide variation. Usually, a busy spring compels the farmer to bend all his energy in getting ready for a seasonable planting. If liming is neglected, it can be performed at time of preparation of seed bed for wheat. The intelligent farmer will use his judgment in choosing a time which is convenient and good if not the best. Lime should not be applied to the surface and immediately plowed under as this tends to place it too far from the surface where it is needed. Neither should the caustic forms (hydrated lime and quicklime) be applied in connection with manure or fertilizers. It is better to plow the manure under and put the lime on top of the soil. In case the manure is desired for top-dressing, the lime should be worked into the soil at least

The easiest way to apply lime is to use a lime spreader.

2 weeks prior to application of the manure. Likewise it is well to apply the lime some time previous to commercial fertilizers.

SPREADING OF LIME

There are various ways of applying lime. The field may be dotted with small piles and the spreading performed with a shovel. This method is laborious. The manure spreader may be brought into use. By tacking fertilizer sacks on the apron, the spreader box may be made tight enough to hold the lime. After spreading the lime, the field should be harrowed crosswise to insure an even distribution. Although not a rapid method it is one which can be used to good advantage in many cases. The most convenient and quickest way of applying the lime is by means of a lime spreader. Lime spreaders can be purchased on the market at prices ranging from $15 to $45. Co-operative ownership of a spreader by three or four men is practical. A spreader, which can be made at home at a cost of from $12 to $15, although somewhat crude, will do the work. Directions for making such a spreader are contained in Bulletin 159 of the Ohio Experiment Station, Wooster, which can be obtained on application to the director of the station.

LIMING NOT ALL SUFFICIENT

Virginia Bulletin, 187 says, "The maintenance of the fertility of * * * depends primarily upon the making, careful saving, and intelligent application of barnyard manure; the maintenance of the supply of humus in the soil, by a proper rotation of crops; and especially by the use of grasses and leguminous crops; upon thorough and judicious tillage and rational use of fertilizers. These practices, and not liming are the main props of soil fedtility. In addition to them, not instead of them, liming is a benefit.

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